# Meteorological and Wave Measurements from a Stable Research Platform at Sea

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## LONG-TERM GOALS

The broad scientific goal of this effort is to advance our understanding of the sea surface wave dynamics and propagation and to develop capability for short-term wave forecasting based on on-board radar observation. An essential element in such effort is to describe and quantify the physical factors primarily responsible for the wave evolution. The wave dynamics on the water side has already been reduced to a computationally-intensive numerical problem (Friehe et al., 2007, section III.B), the complexity of which is determined by the number of nonlinearly interacting wave modes. The wind driving of the waves on the other hand, considered to introduce a wave amplitude growth of the order of a percent per period for physically meaningful wave ages, is less understood. The traditional approach of encapsulating the complex physics of ocean-atmosphere interaction into exchange coefficients (e.g. drag coefficient), is unsuitable for phase-resolving forecasts, hence the need for a mechanistic description of the wind input. Such description is now hindered by gaps in theoretical knowledge and in techniques for numerical modeling. Specifically, the observational validation for most of the wind-wave interaction mechanisms proposed so far in theoretical works is lacking. Little is yet known on how to incorporate realistic multi-mode wave fields in models of air flow over waves or what is the proper SGS parameterization for the air flow LES. The goal in this effort is to deliver progress on these open issues.

## OBJECTIVES

The objective summarizing this effort is to develop a phase-resolved description of the structure and dynamics of the marine atmospheric boundary layer that will be suitable to incorporate in models for short-term wave prediction. Such description should account for all the mechanisms responsible for wind-wave energy transfer. The mechanisms proposed so far fall into these broad categories: (i) random (Langevin's) force mechanism; (ii) wave--mean-flow interaction mechanism; (iii) wave-turbulence interaction mechanism; (iv) nonlinear mechanisms, including sheltering and flow separation. So far, only the wave--mean-flow interaction mechanism has been identified as active in field observations (Hristov *et al.*, 2003). Achieving the formulated goal requires that we identify all the active mechanisms in observational data and quantify their contributions to the wind-wave growth.

Ensuring the practicality of wave forecasts requires that we explore both the dynamical and numerical causes of uncertainty and the propagation of that uncertainty from the radar observations of the surface, through the models and mechanisms employed, to the wave prediction results. The horizon is the natural spatial limitation for the radar, establishing a limitation for the time to produce a forecast. Understanding the uncertainty causes and propagation will let establishing the limits (horizon) of predictability and will allow formulating a criterion for an optimal compromise between dynamic

completeness and computational efficiency of the forecasting models, so that the forecasts are produced within the imposed time limits.

## APPROACH

The planned approach consists of interpreting and assimilating the field data that are going to be collected in the field experiment within this project. The data on atmospheric pressure fluctuations will serve for estimating the direct wind input to the waves occurring through wave—mean-flow interaction mechanism. The wind velocity measurements are key to identifying traces of wave-turbulence interaction and its contribution to the wave growth. Analysis of data from the wave-follower will be used to detect instances of flow separation (a nonlinear mechanism), to determine its statistics and hopefully, its energetics.

The work outlined here will be conducted in close collaboration with other members of the project's team. The work on the field experiment will be carried out with Carl Friehe (UCI), Michael Banner (UNSW). Interpretation of radar observations of the sea surface and the work on incorporating realistic sea surfaces into atmospheric boundary layer models will be done with Eric Terril (UCSD) and Peter Sullivan (NCAR).

## WORK COMPLETED

Project is in its preliminary stage. The work so far has included reviewing literature and planning the field experiment. Laboratory testing of instruments and data acquisition system hardware components, preparation of cabling, mounting gear, and development of software have been carried out. Acquiring the components, the assembly and the testing of the instruments for measuring atmospheric pressure fluctuations will be done in the time before the trial cruise, scheduled for the fall of 2008.

## RESULTS

Since the experiment has not been performed yet, there are no reportable results.

## IMPACT/APPLICATIONS

The results of this research are to be incorporated in operational models for short-term wave modeling and forecasting. The newly acquired knowledge regarding the structure and dynamics of the marine atmospheric boundary layer (MABL) and the statistics of the ocean surface will advance the description and modeling of signal propagation over the ocean. The profound physical similarities between propagation of radar signals over the ocean and acoustic signals in the water will extend possible applications to the acoustic domain. Since the MABL structure and dynamics is also essential in designing and modeling the performance of flying objects operating close to the ocean surface, such engineering applications of this project results are foreseeable as well.

## RELATED PROJECTS

The PI is unaware of any related projects.

## REFERENCES

C. Friehe, K. Melville, and D. Yue (steering committee), High Resolution Air-Sea Interaction DRI Science Plan, 2007.

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